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APPLICATION FOR UNITED STATES PATENT

Title: **METHOD AND DEVICE FOR DELIVERING FLUID, AND A HEAT TRANSFER CARTRIDGE**

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SUBSTITUTE SPECIFICATION

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METHOD AND DEVICE FOR DELIVERING FLUID, AND A HEAT TRANSFER CARTRIDGE

Field of the Invention

The invention generally concerns a method and device for delivering a fluid such as a gas or a liquid.

Background of the Invention

In many industrial applications, fluid materials (fluids) are delivered with the aid of fluid-delivery devices and deposited on or applied to substrates. The fluid materials may be, for example, adhesives, paints, or sealing materials, and the substrates may be personal care products, plastic sheets, furniture, machine parts, or the like. Depending on the application, the fluid materials may be delivered, for example, in the form of beads, strips, or films, or the material may possibly be sprayed with the aid of a gas jet that affects the fluid. The fluid-delivery devices are connected to a fluid source, for example, an adhesive reservoir, and the fluid is fed by a pump through so-called application valves to a discharge orifice, which is, for example, circular or slot-shaped.

In some applications, it is advantageous to heat the fluid before it is delivered. In spray processes, it may be advantageous to heat a gas that

acts on the fluid to be delivered. For this purpose, it is well known that the base of the delivery device can be electrically heated, so that liquid or gas flowing through flow channels formed in the base is heated by convective heat transfer at the inner wall bounding the flow channel. To heat a gas in a fluid-delivery device, it is well known to use a gas flow channel that follows a zig-zag pattern. The purpose of the zig-zag design is to lengthen the flow path available for heat transfer and in this way improve the heat transfer. However, this has the disadvantage that the designs needed to produce this type of flow path are very involved and thus expensive.

The goal of the present invention is to develop a method and device of the type described above and a cartridge to improve heat transfer.

Summary of the Invention

The invention achieves the goal with respect to a method of the type described above in such a way that, before it is delivered through the discharge orifice, the fluid is heated or cooled by flowing through a heat-transfer chamber. The heat-transfer chamber contains a fluid-permeable structure or foraminous body with a large number of communicating cavities or interconnected interstices, such that the fluid circulates through this structure.

Furthermore, the invention achieves the goal with respect to a device of the type described above by a heat-transfer chamber for heating or cooling the fluid, which contains a fluid-permeable structure with a large number of communicating cavities.

The advantages of the invention include significantly improving the heat transfer for heating or, alternatively, cooling a liquid and/or a gas

before it is delivered by the delivery device. More specifically, this advantage is achieved by the fluid-permeable structure of the invention through which the fluid circulates. The fluid-permeable structure is preferably a sintered material, especially a sintered metal, which is essentially rigid and has a large number of intercommunicating cavities through which the fluid can circulate. Due to the fluid-permeable structure present in the flow channel of the heat-transfer chamber, the heat transfer is improved by virtue of the fact that the surface area between the structure and the fluid to be heated or possibly cooled, which is crucial to the transfer of heat, is greatly increased and multiplied. The structure is heated and the heat can be transferred to the fluid over the large surface area of the structure. Furthermore, the heat transfer is improved by the fact that the fluid is repeatedly deflected as it flows through the structure. This produces a certain amount of turbulence which, in turn, results in improved heat transfer.

In accordance with the invention, the heat transfer involved with, for example, the heating of a liquid or a gas, is thus significantly improved and, as a result, the device can be built relatively compactly. Especially in the case of the heating of compressed gas for delivery devices for spraying liquids, such as hot-melt adhesives, the increased flow resistance produced by the fluid-permeable structure, compared to a free-flow channel, is negligible. The use of sintered metal as the preferred material has the advantages that it has a large internal heat-transfer surface, is dimensionally stable, is easily produced and processed, and thus can be adapted to specific applications. Alternatively, however, it is also possible, in accordance with the invention, to use other

open-pored, preferably essentially rigid, structures, such as fabrics, metal braids, or rigid, open-pored cellular plastics.

Advantageously, as the fluid flows through the heat-transfer chamber, it can be heated or cooled and simultaneously filtered by the fluid-permeable structure, so that, in addition to being heated, a gas or liquid is also purified.

To introduce heat into or remove heat from the fluid, the fluid-permeable structure is preferably in contact with the inner surface of the heat-transfer chamber. In this way, efficient heat transfer occurs.

It is especially preferred for the fluid to be a liquid, especially a fluid plastic, such as a hot-melt adhesive, and for it to be heated by flowing through the heat-transfer chamber. It is likewise preferred for the fluid to be a gas, preferably air, and for it to be heated by flowing through the heat-transfer chamber, which is advantageous in spray applications.

The device of the invention is refined by a simple design modification by forming the heat-transfer chamber as a section of the flow channel, into which the fluid-permeable structure is inserted. In this way, the heat-transfer can be improved in a flow channel formed in a housing or base of the delivery device in a simple way by inserting a fluid-permeable structure of the invention.

It is especially preferred for the fluid-permeable structure to be designed essentially as a cylindrical body, which is inserted in an essentially cylindrical bore. This allows simple production and installation as well as replacement of the fluid-permeable structure.

A further advantage is realized if the fluid-permeable structure is a mechanically finished sintered metal part, preferably a turned sintered metal part. The heat transfer between the sintered metal part and the heat-transfer chamber is further improved by mechanical finishing, e.g., turning, of a surface of the sintered metal part that is in contact with the heat-transfer chamber. As a result of the turning, the outer pores are partially sealed, and a larger contact surface is produced, without adversely affecting the inner structure, through which the fluid flows.

Advantageously, the heat-transfer chamber is formed in a metal housing, and the housing contains heating elements for heating the housing.

It is especially preferred for the fluid-permeable structure to be designed as part of a cartridge that can be inserted in the device. The cartridge is detachably mounted in the device, and the fluid flows through it. This allows fast and easy replacement of the cartridge. It is advantageous for the cartridge to have at least one heating element.

In accordance with an alternative embodiment, it is proposed that the device have a base, in which the one or more heat-transfer chambers are installed, and that one or more application modules are provided, which are installed on the base and contain the discharge orifice for delivering the fluid. If needed, several heat-transfer chambers can be connected in series or in parallel. They are preferably installed in separate housing sections, which can be attached to one another.

Additional advantageous modifications will become apparent upon further review of the specification.

Brief Description of the Drawings

The invention is described below on the basis of preferred embodiments illustrated in the attached drawings.

Figure 1 shows a fluid-delivery device of the invention in a side view.

Figure 2 shows the device in Figure 1 in a different side view.

Figure 3 shows a partial section of the device in Figure 1.

Figure 4 shows an alternative embodiment of several heat-transfer chambers for a device in accordance with Figure 1.

Figure 5 shows an alternative embodiment of a fluid-delivery device, in which the fluid can be heated in accordance with the invention.

Figure 6 shows a perspective view of a cylindrical sintered metal part.

Figure 7 shows a perspective view of a cartridge for the fluid-delivery device.

Figure 8 shows a perspective view of an alternative embodiment of a cartridge.

Figure 9 shows another alternative embodiment of a cartridge.

Detailed Description of the Preferred Embodiments

The device shown in Figures 1-3, which is also known as an applicator head or fluid-delivery device, is used to deliver and apply liquids, such as adhesives, hot-melt adhesive, cold glue, sealants, or the like, to various substrates. The device 1 comprises a metal base 2 and four delivery or application modules 4, 6, 8, 10, each of which is screwed onto the base 2 and

from which the fluid is delivered through at least one discharge orifice 12. The application modules 4, 6, 8, 10 may also be supplied with compressed gas, which emerges in the region of the discharge orifices 12 through compressed gas nozzles and acts on the fluid in such a way that the fluid is sprayed or swirled. The substrate to be coated is conveyed past the device 1 below the discharge orifices by conveyance devices that are not shown in the drawings, for example, in the direction indicated by arrow 14. The device 1 can be mounted on support structures by fastening screws 16 fastened to the base 2.

A hose connection socket 18 serves to connect the device 1 with a fluid source, such as an adhesive reservoir for liquid adhesive (not shown). The adhesive is conveyed through a flow channel which is composed of several sections and runs through the base 2 and into the application modules 4, 6, 8, 10 as far as the discharge orifices 12. The adhesive flow channel has a first bore 20, which is shown only schematically by the broken line, a transverse distribution channel 22, oblique bores 24, which communicate with the transverse distribution channel 22 and lead to each of the modules 4, 6, 8, 10, and additional channels, which are formed inside the application modules 4, 6, 8, 10 and open into the discharge orifice 12.

To allow selective starting or stopping of the flow of the adhesive inside the device 1, each module 4, 6, 8, 10 contains a valve system (not shown in detail), which has a valve body that can be moved pneumatically from an open to a closed position and interacts with a valve seat. The valve system is operated by an electrically controllable solenoid valve 26, control air lines 28 connected to the solenoid valve, and compressed gas channels formed in the

base 2, which are only indicated by the broken lines 30, 32 and serve to introduce compressed gas into the application modules 4, 6, 8, 10.

An air connection socket 34 is installed on the base 2 to supply gas, e.g., in the present embodiment, compressed gas. The compressed gas flows through several compressed gas channels, which are described in greater detail below and are used for spraying or swirling the fluid delivered through the discharge orifice 12.

For heating the spraying gas, preferably air, several heat-transfer chambers 36, 38, 40, 42, 44, 46 are formed inside the base 2. The gas flows through the heat-transfer chambers in the direction indicated by the arrows. In the present embodiment, there are two series-connected preheating heat-transfer chambers 36, 38 and four additional, parallel-connected heat-transfer chambers 40, 42, 44, 46, each of which is assigned to an application module 4, 6, 8, 10. Alternatively, however, depending on the specific application, there may be different numbers of series-connected or parallel-connected heat-transfer chambers or even only a single heat-transfer chamber. The heat-transfer chambers 36, 38, 40, 42, 44, 46 are arranged parallel to one another in a plane in the upper section of the base. As Figures 2 and 3 show, the base 2 is composed of several housing sections, which are fastened to one another by screw joints. Each housing section holds at least one heat-transfer chamber and serves to mount one of the application modules 4, 6, 8, 10.

A fluid-permeable structure that contains a large number of communicating cavities is provided in each heat-transfer chamber. In the embodiment shown here, the structure is formed by cylindrical sintered metal parts 48. The heat-transfer chambers with the fluid-permeable structures

arranged within them serve primarily to improve the heat transfer, i.e., in the present embodiment, to improve the heating, of the gas flowing through the fluid-permeable structure. The sintered metal parts are essentially rigid and may consist, for example, of a bronze-copper alloy. Alternatively, however, the fluid-permeable structure may also consist of metal fabric, metal braid, or an open-pored, rigid cellular plastic material, through which gas or liquid can flow.

The sintered metal parts 48 are cylindrical and are fitted to and inserted in cylindrical bores 50 formed in the base 2. The addition or removal of heat is explained in detail below. Each bore 50 is formed as a through-hole in the base or, more precisely, its housing sections. The sintered metal parts 48 can be inserted from the inlet ends 52, which are readily distinguishable in Figure 3, of the bores 50. Both the inlet ends 52 and the opposite ends 54 of the bores 50 are provided with internal threading, and, in the operating state, in a way not shown here, can be sealed gastight with screw-in plugs. The gas introduced through the intake socket 34 flows through the heat-transfer chamber 36, then through a transverse bore 56 into the heat-transfer chamber 38, then through a transverse bore 58 into the heat-transfer chamber 40, and finally into the application module 4. The gas also continues to flow through the additional transverse bores 60, 62, 64 into the corresponding heat-transfer chambers 42, 44, 46 and then into the corresponding application modules 6, 8, 10. To exchange the sintered metal parts 48, the plugs screwed into the inlet ends 52 are removed, and the sintered metal parts are taken out, possibly with the use of tools, which can be inserted through the opposite ends 54 to push out the sintered metal parts 48.

To supply heat to the heat-transfer chambers 36-46 and the fluid-permeable structures (sintered metal parts 48), electric resistance heaters are installed inside the base 2, namely, inside several heater bores 58, 60, as Figure 1 shows. In a way not shown in the drawings, electric resistance heaters in cylindrical form are inserted in the bores 58, 60 and are supplied by electric current through connections 62 to the bores 58, 60. The resistance heaters constitute heating elements for heating the base 2. Thermal energy is transported through the base 2 by thermal conduction, so that the individual heat-transfer chambers 36-46 and the fluid-permeable structures inserted in them can be heated to a sufficient temperature for thermal energy to be transferred to the gas flowing through the fluid-permeable structure, and the gas is heated. Heat transfer is significantly improved by the fluid-permeable structure, since the surface area available for the heat transfer is significantly increased, and the gas circulating through the structure is deflected and thus stirred up, which causes a certain amount of turbulence, which in turn promotes heat transfer. In a way not shown in the drawings, instead of heating elements, coolants could be provided for cooling the base 2 and thus reducing the temperature of the heat-transfer chambers 36, 38, 40, 42, 44, 46 and the fluid-permeable structure, for example, by introducing a coolant, such as a cooled gas or a liquid coolant, into the bores 58, 60.

Figure 4 shows a sectional view of an alternative embodiment of a device 1, which has a design that is basically similar to that of the device 1 described with reference to Figures 1-3. The differences from the device 1 described with reference to Figures 1-3 are explained below; otherwise, the above description applies completely to this alternative embodiment. The base

2 shown in Figure 4 holds three application modules, which are not shown in the drawing, to which three heat-transfer chambers 42, 44, 46 are assigned and can be installed in the same way as shown in Figure 3. Two heat-transfer chambers 36, 38 connected in series are formed in a housing section 64 on the left side in Figure 4. The fluid-permeable structures in the form of sintered metal parts 50 are likewise inserted in cylindrical bores 48. Inlet ends 52 are provided for this purpose, which can be sealed by plugs, which are not shown in the drawing. Gas to be heated is introduced through the intake 66. The gas can then flow through transverse bores 56, 58, 60 and 62 to the individual heat-transfer chambers 42, 44, 46 connected at the outlet ends of the transverse bores.

Figure 5 shows an alternative embodiment of a fluid-delivery device in accordance with the invention, in which a liquid, such as hot-melt adhesive, is heated or cooled by a heat-transfer chamber 68 and a fluid-permeable structure formed in it. As was explained in detail above, the fluid-permeable structure is preferably designed as a cylindrical sintered metal part 70, which is inserted in a cylindrical bore 72 formed in a base 2, so that there is contact between the sintered metal part 70 and the inner surface of the bore 72. As was also explained earlier with reference to the first embodiment, the description of which completely applies here, the base 2 can be heated by heating elements, preferably electric heating elements, or cooled by coolants in a way not shown in Figure 5, so that the adhesive flowing through the fluid-permeable structure is heated or cooled in the heat-transfer chamber 68 with the aid of the sintered metal part 70, as the adhesive flows in the direction of arrow 74 from a fluid source connected by a connection socket 18, through the

heat-transfer chamber 68 and through a bore 76 at the outlet of the heat-transfer chamber, to at least one application module 4, which has a discharge orifice 12 for delivering the fluid.

Figure 6 illustrates a fluid-permeable structure in accordance with the invention in the form of a cylindrical sintered metal part, which can be inserted in a flow channel for a liquid or gas to be delivered by a delivery device 1 and is used for heat transfer, preferably for heating. The liquid or gas can be filtered at the same time. After it has been sintered, the sintered metal part 48 can be mechanically finished on its outer cylindrical surface, preferably by turning, so that the pores located on the cylindrical surface are partially sealed by deformation, which results in the formation of an increased surface in contact with the inner wall of a bore into which the sintered metal part 48 is inserted. The heat transfer is further improved in this way. Alternatively, in a way not shown in the drawing, it is also possible to place several separate sections of sintered metal parts one after another in a row in a heat-transfer chamber.

Figure 7 shows a cartridge 70 in accordance with the invention, which is intended to be inserted in a fluid-delivery device 1, for example, a device of the type specified in the above descriptions. The cartridge 70 can be detachably installed in a heat-transfer chamber 36, 38, 40, 42, 44, 46, for example, with the use of plugs, bayonet sockets, screw fittings, or the like. The cartridge 70 has an external heating element 72 in the form of a hollow cylinder. The heating element 72 is furnished with a large number of electrical conductors (not shown), which generate heat when an electric current flows through them. Electric connections (not shown) are provided for this purpose.

The fluid-permeable structure of the invention in the form of a cylindrical body 74, preferably a sintered metal part that fits into the cavity of the hollow cylinder, is formed inside the heating element 72. When the cartridge 70 is inserted, a liquid to be heated, for example, a hot melt adhesive, or a gas to be heated, for example compressed air, flows through the fluid-permeable structure of the body 74 in the manner described earlier, so that heating occurs.

The alternative embodiment of a cartridge 71 of the invention that is shown in Figure 8 differs from the cartridge 70 described with reference to Figure 7 in that no heating element is provided; instead, a housing in the form of a tube 73 is provided, which holds the fluid-permeable structure, which is designed as a sintered metal part. The tube is made, for example, of aluminum or of another material that is a good heat conductor. Two grooves 76 are formed on the outer cylindrical surface of the tube 73 near the ends of the tube, into which gasket rings, for example, O rings, can be inserted in a way not shown in the drawing to form a seal against a bore of the heat-transfer chamber in a base 2, so that the fluid to be heated flows in a well-defined way through the fluid-permeable structure, which is designed as a sintered metal part 74.

The alternative cartridge shown in Figure 9 has a centrally installed electric heating element 80 and a fluid-permeable structure in the form of a sintered metal part, which is designed as a hollow cylinder 82, in whose inner cavity the heating element 80 is tightly fitted. As explained earlier, the cartridge 78 is likewise placed and detachably fastened in a base of a fluid-delivery device 1, and fluid flows through the sintered metal part 80, so that it is heated.

In the example shown in Figure 5, the hot-melt adhesive is heated in the heat-transfer chamber 68 and fed into the application module 4.

As illustrated in Figures 1-3, liquid flows through the connection socket 18 into the base 2 and the modules 4, 6, 8, 10 and is then delivered by the discharge orifice 12. Gas flows through the connection socket 34 and into the base 2 and, in accordance with the invention, is heated by flowing through heat-transfer chambers 36, 38, 40, 42, 44, 46, possibly with the use of cartridges of the type illustrated in Figures 6-9. To this end, the inner wall of the heat-transfer chambers 36, 38, 40, 42, 44, 46 and the fluid-permeable structure are heated by heating elements or, in the case of cooling, cooled by coolants. The heated or cooled gas then continues to flow through the base 2 and into the application modules 4, 6, 8, 10 and then, in its heated state, acts in such a way on the liquid to be delivered that atomization, turbulent swirling, or the like occurs.